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# Development of a Vehicle Independent Surveillance Data Collection System

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The 3rd Integrated Communications, Navigation, and Surveillance Conference & Workshop
Annapolis, Maryland
19-22 May, 2003

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# Introduction

- FAA Surface Technology Assessment Product Team tasked to develop and execute a surface technology program aimed at reducing runway incursions

- Runway incursion: “Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off, intending to take off, landing or intending to land”

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# Introduction

- FAA deploying a multilateration system (surveillance and ID of transponder-equipped aircraft/vehicles) at DFW
- Optimization and acceptance testing requires comparison between data collected by the sensor and truth data (known, precise data provided by the vehicle being tracked)

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# Introduction

- Volpe Center tasked design and develop portable suite of equipment for ground truth data collection
  - Cost effective
  - Flexible power source
  - Readily transportable
  - Quick system setup and easy to operate
- Portable Airport Surveillance Verification System (PASVS): portable, government/rental vehicle deployment, intuitive operation, AC or DC power, ruggedized (field use, shipping)

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# Major Component Integration

- Modular design/COTS used to speed development time, minimize risk, and ensure reliability and maintainability
- VHF aircraft radio (Icom A200m; 7W)
- DGPS (Trimble AgGPS 132; 5 Hz, Nationwide DGPS/WAAS/subscription)
- ATCRBS transponder (Garmin GTX 327)
- Mode S transponder (Bendix/King KT70)
- Computer with data logging software

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# PASVS radio electronics

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# Major Component Integration

- Mode C:
  - Determine desired true airport surface MSL
  - Current barometric sea level pressure
  - Obtain aircraft indicated altitude using:

$$H(\text{aircraft\_indicated}) = H(\text{airport\_surface\_true}) + 925 * (29.92 - BPSL)$$

  - Equivalent 12-bit Gray code from lookup table
  - Manually set via dozen thumbwheel or toggle switches
  - Does not allow for barometric pressure variation over time (test runs up to 8 hours)
  - Changes in mean sea level elevation with position (100’ at DFW)
  - Potential operator error
  - Ameri-King AK-350 Digital Blind Encoder eliminated a potential source of altitude data error, made the unit easier to operate by automating mode C

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# Major Component Integration

- Power:
  - VHF radio: $13.8 \pm 2.1$ VDC
  - Transponders: 11 to 33 VDC
  - AC power supply provides 15 VDC from 85 to 265 VAC at 47 to 440 Hz
  - DC power provided by the vehicle's 12-VDC outlet through 15-VDC regulator (since power supplied by vehicle battery alone unregulated)
  - On vehicle DC power, automatic switching circuit senses DC power and routes through a DC-to-DC converter to maintain steady 15 VDC from 9 to 18 VDC
  - In trials, power supplied to the equipment has been sufficient

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# Major Component Integration

- Enclosure:
  - Portable, lightweight, ruggedized equipment enclosure
  - 35 lbs., 24” x 12” x 17.5”
  - Aluminum faceplate with connections for power, antennas, and laptop computer data interface
  - MILSPEC connectors
  - Internal coax storage

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# PASVS equipment enclosure

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# Major Component Integration

- Antennas:
  - High strength magnetic antenna mounting system
  - Four antennas
  - Dipole transponder antennas used
  - 10-inch diameter ground plane installed on each transponder antenna
  - GA aircraft mods for greater radio signal attenuation
  - Calculations indicated 9.8 dB of attenuation required (3’ belly mount same as 7’ test vehicle mount)
  - Actual cable loss of 3.8 dB, an additional 6 dB of attenuation was integrated

# Initial antenna configuration


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# Data Collection System

- Written in Visual C++, runs in Windows OS
- GUI for recording the GPS location of the test vehicle
- Free-form message stored in the header of each log file
- Automatically creates filename in accordance with current month-day-year
- Adjustment of comm port parameters from within the application

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# Data Collection System

- Data activity window and timers provide visual feedback on progress and testing status
- Visually and audibly warns when DGPS corrections not being received
- Data-Power port supplies notebook power and DGPS data output through a single connector
- 5-pin MILSPEC port; cable splits to a power plug and DB9 to expedite equipment setup
- Recorded data quickly transferred to compact disk through external CD-recorder

# PASVS operational configuration

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# Benchmarking and Testing

- Operational PASVS tests concurrent with multilateration system optimization
- Lab tests included: transponder power output, MTL, transmission line losses, and VSWR
- IFR ATC-1400A Transponder Test Set and IFR S-1403 DL/MLD Mode S Accessory Unit
- Both transponders met minimum performance requirements
- Accuracy of DGPS receiver evaluated using low frequency radio beacon system and WAAS corrections at multiple survey points
- Four locations (each quadrant of DFW) and one at the airport’s center

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# Summary of transponder tests

| | Garmin GTX 327 ATCRBS | Bendix/King KT 70 Mode S |
|---|---|---|
| MTL | - 76 dBm | - 77 dBm |
| Output Power | 220 Watts | 273 Watts |
| Cable Loss | 9.8 dB[1] | 3 dB |
| Ant. VSWR | 1.4 : 1 | 1.4 : 1 |

Note 1. Including an in-line 6 dB attenuator

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# Benchmarking at a typical survey monument

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# Benchmarking and Testing

- DGPS data was collected minimum of 10 minutes
- Recorded data indicated the DGPS performed with a horizontal accuracy of 2.5 m or better at 95%
- PASVS operated and performed as designed during the test period
- Experienced no system breakdown, equipment malfunction, or requirement for special handling or operation
- Ease of use and quick deployment well received by various, novice operators.

# DFW test vehicle ground track data

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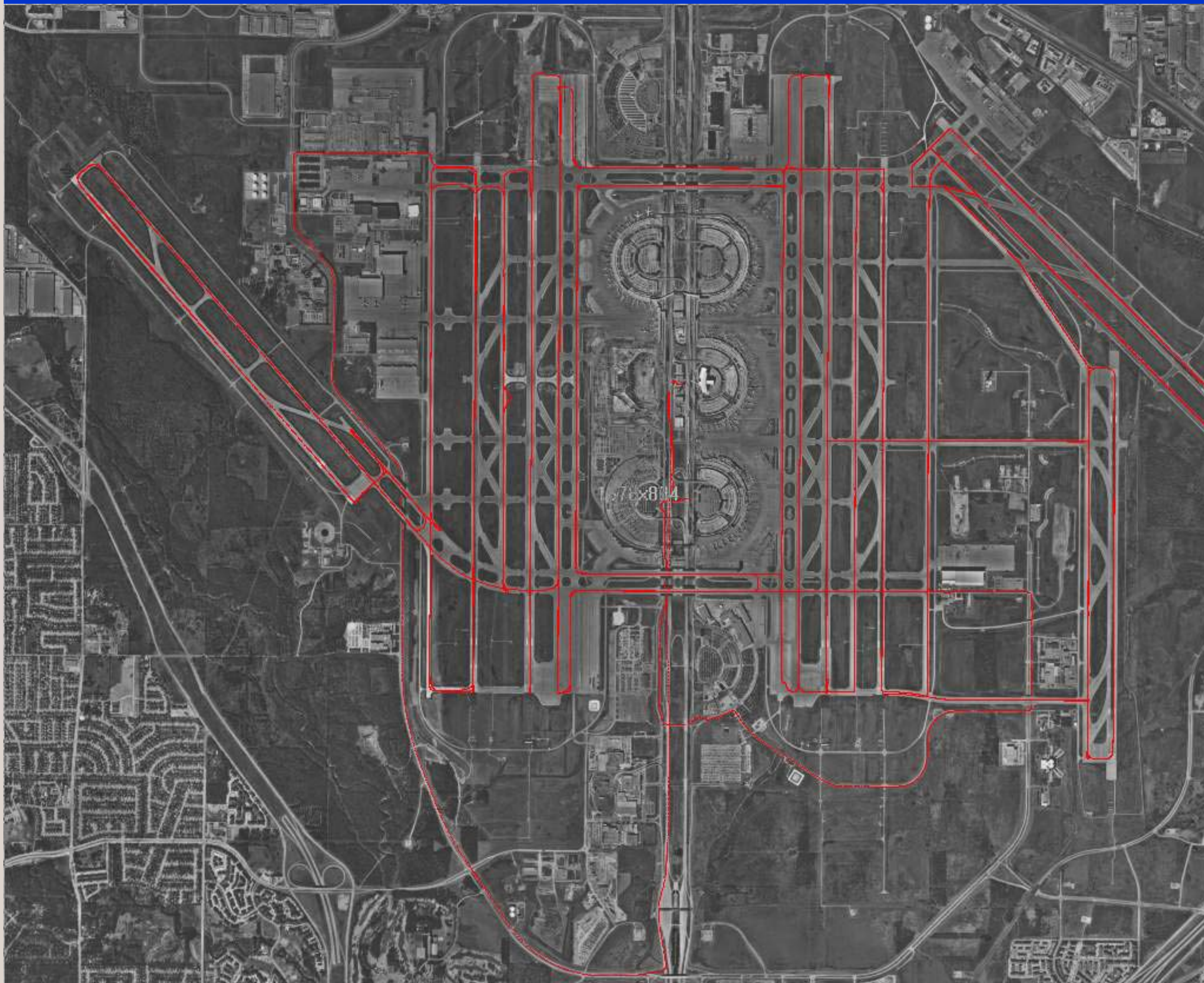

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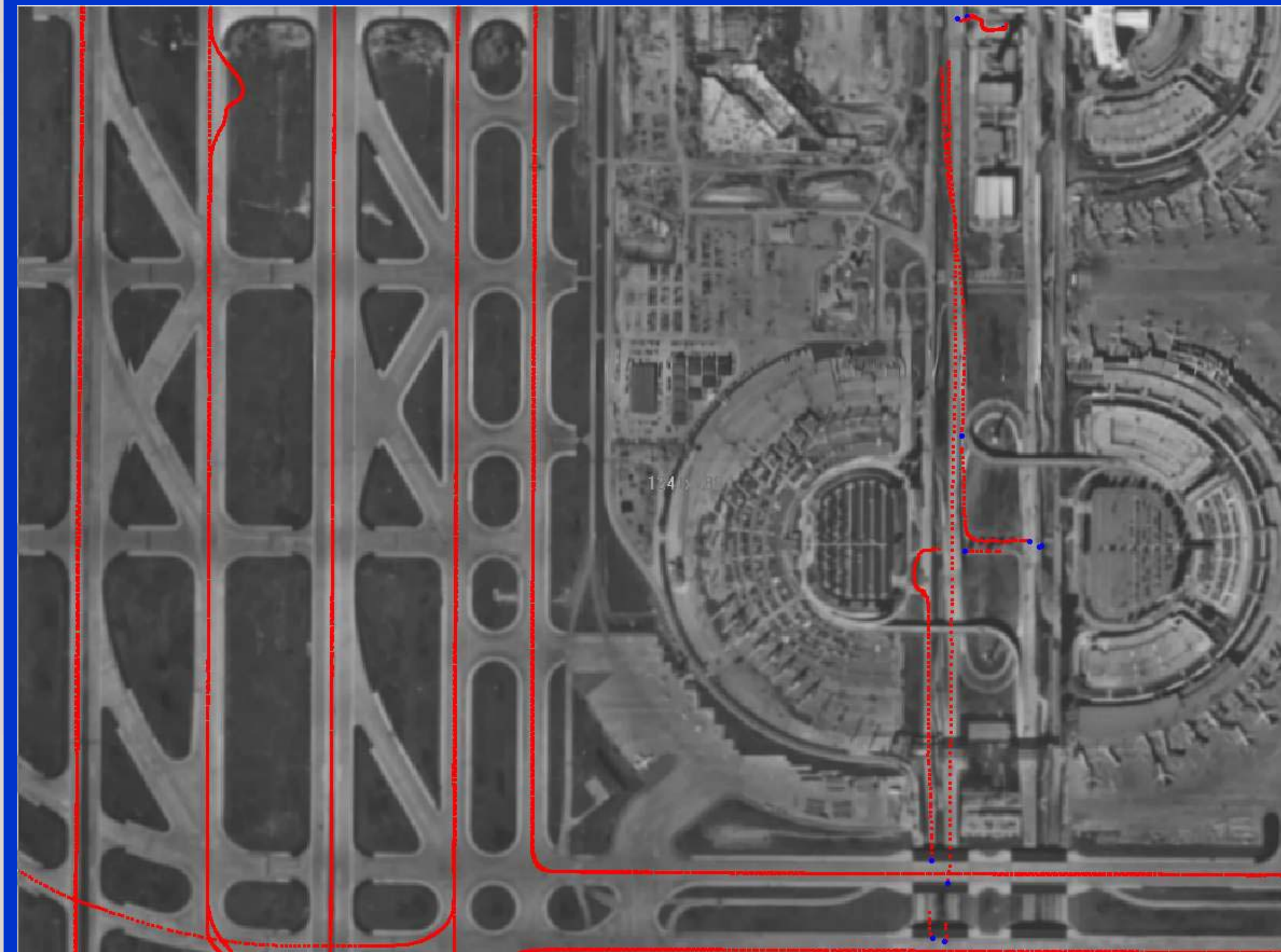
# Magnified view of the south-central section at DFW



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# Conclusions

- The PASVS has been shown to be:
  - Capable data collection platform to support ground truth measurements at airports
  - Easily and quickly shipped to various locations
  - Rapidly installed and configured
  - Operated from any ground vehicle by a single operator with minimal training
- The system shows promise for future use in production and prototype airport surveillance systems:
  - Optimization
  - Test
  - Maintenance


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# Acknowledgements


- Based on work supported by the FAA Runway Incursion Reduction Program through the Surface Technology Assessment Product Team

- Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors